Fabrication and Analysis of Jute and Flax Fiber Reinforced Biocomposites

Faraj Alam, Mohd Anas

Department of Mechanical Engineering, Integral University, Lucknow

Abstract - Biocomposite materials have gained substantial attention as sustainable alternatives to conventional materials in various industries. This research paper presents a study on the fabrication and testing of biocomposites using jute, and flax fibers as reinforcements and polypropylene (PP) as the matrix. The injection molding technique is employed for the fabrication process. The paper investigates the influence of fiber loading and fiber types on the mechanical properties, and biocompatibility of the biocomposites. The results demonstrate the potential of jute, wood, and flax fiber-reinforced PP composites and their suitability for different applications, highlighting their eco-friendly nature and improved performance.

***Key Words*:** Biocomposite Materials, Jute and Flax fibers, Testing of Materials

2. Body of Paper

1. Introduction 1.1, Objectives of the study 1.2
2. Injection Moulding Process 2.1 Treatment of fiber 2.2. Injection Molding Parameters 2.2.1
3. Mechanical Property Evaluation 3.1

Introduction 1.1

Bio composites are a sort of composites that are planned exclusively for bioengineering applications. With the exception of the extra biocompatibility prerequisite, every one of different issues connected with a bio composite are likewise met by a standard composite. These issues incorporate choice of the constituent materials, creation from the constituents into the composite, mechanical, physical, and mathematical portrayals of the composite and its constituents, and investigation and plan of the composite to best accomplish the application reason. While different issues have been tended to with representations, the investigation and configuration issue is a primary focal point of this article. Connecting Model along with the lattice genuine pressure hypothesis can accomplish a base up planning reason. It is relevant to any two stage composite produced using nonstop filaments, short strands or particles and the grid, as long as the void substance in the composite can be ignored. One just has to give the constituent property boundaries and the fiber or molecule mathematical information, and the mechanical ways of behaving of a bio composite can be determined scientifically. Bio composites can be used alone, or as an enhancement to standard materials, similar to carbon fiber. Advertisers of bio composites express that use of these materials further foster prosperity and security in their creation, are lighter in weight, have a visual charm like that of wood, and are naturally superior. The best technique to gain the other real despite the mechanical properties of the composite from those of its constituents isn't concerned in this article.

Objective of the study 1.2

The objective of the study on biocomposite materials is to characterize, optimize, and assess their suitability for various applications while considering their environmental sustainability. This involves investigating the composition, structure, and properties of biocomposite materials to understand their performance and potential advantages over conventional materials. The study aims to identify opportunities for improving the formulation and manufacturing processes of biocomposites to enhance their mechanical strength, durability, and other desired properties. Additionally, it seeks to evaluate their environmental impact, life cycle sustainability, and economic feasibility, with the ultimate goal of promoting the adoption of biocomposite materials as a sustainable alternative in different industries and sectors.

Injection Moulding Process 2.1

Injection molding is a manufacturing process widely used for the mass production of plastic parts. It involves injecting molten plastic material into a mold cavity under high pressure and then allowing it to cool and solidify, resulting in the desired shape of the final product. The process begins with the preparation of the plastic material, typically in the form of pellets or granules, which are fed into a heated barrel. The material is then melted and forced into the mold cavity through a nozzle using a screw or plunger mechanism. The high pressure helps ensure the material fills the entire mold and takes on its shape. Once the plastic has solidified, the mold is opened, and the finished part is ejected. Injection molding offers several advantages, including high production efficiency, repeatability, and the ability to produce complex shapes with precise dimensions. It is widely utilized in industries such as automotive, electronics, medical, and consumer goods, among others.

Treatment of Fiber 2.2

The strategy incorporates water washing and drying. Customary strands are isolated from their parent plant. The Jute are isolated from the back of their stems, while wood are ex-tracted from their plant. Flax fiber is removed from the stems of the flax plant, deductively known as Linum usitatissimum. The fiber is obtained from the inner bark or phloem of the plant, which surrounds the woody core or hurd. Flax plants are annuals that grow to a height of about 1-1.5 meters (3-5 feet) and have slender stems with multiple branches. The treated fiber was permitted to dry in the sun for 3 days. After which the filaments are laid in the shape with the tar at the proportion of 20% to 60%

Injection Moulding Parameters 2.2.1

INJECTION MOULDING PARAMTERS	VALUE
Volume	50 cm (flat specimen) 44 cm (tensile specimen) 42 cm (bending specimen)
Injection Pressure	Variable according to fibre content
Switch-Over Point	12 cm
Injection rate	50 cm
Holding Pressure	600 bar
Holding time	20 s
Residual Cooling time	30 s
Screw rotational speed	15 m/min
Back Pressure	30 bar
Decompression Volume	5 cm
Decompression Rate	5 cm
Temperature of the first zone	165°C
Temperature of the second zone	175°C
Temperature of the third zone	180°C
Temperature of the fourth zone	185°C
Temperature of the fifth zone	190°C
Temperature of the Mould	20°C

Mechanical Property Evaluation 3.1

In This research we basically evaluate Three Types of Mechanical Property in order to Test our Fabricated Product that is Tensile Test on Universal Testing Machine, Hardness Test on Brinell Hardness Machine as well as Impact test Charpy Pendulum Impact Testing Machine.

REVIEW OF LITERATURE

Biocomposite materials have gained significant attention in recent years due to their potential as sustainable alternatives to traditional materials. Numerous studies have focused on investigating the properties, fabrication methods, and applications of biocomposites. Here is a brief overview of the key findings from the literature

Shukla.et al [1] (2014). Biocomposites

Fabrication, Properties , and Applications – A Review,. International Journal of Innovative Research in Science, Engineering, and Technology. Polymers structure the spines of plastic materials, and are constantly being utilized in an extending scope of regions. Accordingly, numerous analysts are concentrating profoundly on changing conventional materials to make them more easy to understand, and into planning novel polymer composites out of normally happening materials. Various natural materials might be integrated into polymer materials. Lately, there has been a noticeable expansion in interest in biodegradable bio-composite material for use in bundling, horticulture, medication, and different regions. The conviction is that polymer bio-composite materials will diminish the requirement for manufactured polymer creation (subsequently lessening contamination) for a minimal price, in this manner delivering a positive result both ecologically and monetarily. This survey is planned to give a short blueprint of work that is in progress in the space of polymer bio-composite innovative work, the logical hypothesis behind these materials, regions in which this exploration is being applied, and future work that is standing by.

Rao. et al [2] A.R., 2010.

A review has been done to examine the elastic, flexural and dielectric properties of composites made by building up vakka as another normal fiber into a polyester gum matrix.The composites are manufactured up to a most extreme volume part of fiber of 0.37 on account of ductile testing, and 0.39 for flexural and dielectric testing. It has been seen that the ductile properties increment regarding volume part of fiber for vakka fiber composite and are additionally more than those of sisal and banana composites and similar to those of bamboo composites.

Bledzki, A.K., Franciszczak, P., Osman et al [3] M., 2015.

This approach gives useful instruments of how to tailor the properties of PP biocomposites by just picking a sufficient fiber type as a lattice support. Besides, the data with respect to: development, cost, and accessibility are contrasted with give an all encompassing perspective for these most normal regular strands for specialized applications in plastic industry.

Raman et al [4] (2013).

The fundamental target of this paper is to create and test the jute bio-composite which is of minimal expense, low thickness, high unambiguous strength, light weight, no wellbeing chances, sustainable, climate amicable and lower energy necessity for handling. The jute composite utilized has gone through salt treatment and mixed with epoxy gum and restored. The later phase of our undertaking manages the Malleable Test, Effect Test and Flexural Trial of the example as per the ASTM principles for Plastics.

Ku, Harry & Wang et al [5] (2011)

This paper is a survey on the tractable properties of regular fiber built up polymer composites. Normal strands have as of late become alluring to specialists, designers and researchers as an elective support for fiber built up polymer (FRP) composites.

Malkapuram, Ramakrishna et al [6] (2009)

This survey article depicts the new advancements of regular fiber built up polypropylene (PP) composites. Normal filaments are minimal expense, recyclable, and eco-accommodating materials. Due to eco-accommodating and bio-degradability attributes of these regular filaments, they are considered areas of strength for as to supplant the ordinary glass and carbon strands.

Mirza, F. A. & Rasel, Sheikh et al [7] (2010)

Infusion forming and mechanical properties assessment of short jute fiber polypropylene built up composites. Composites with polypropylene (PP) and 2 wt% NaOH treated jute strands were ready by the infusion shaping procedure. To work on the liking and attachment between the supported jute fiber and the polymer matrix(polypropylene) during assembling,

Bledzki, Andrzej et al [8] (2006)

Tractable and flexural tests are performed on the frothed composites to research the reliance of these properties on the thickness (explicit properties) of frothed examples and contrasted and non-frothed composites and MAH-PP has worked on the physico-mechanical properties up to 80%. Synthetic frothing specialists affect surface unpleasantness of the composites which diminished surface harshness of the frothed composites contrasted with the non-frothed composites. Water ingestion and thickness enlarging of the composites examined moreover.

Kumar, Anuj et al [9] (2020)

Infusion formed biocomposite examples were ready by utilizing four different weight rates, i.e., 10%, 20%, 30%, and 40% of aspen (Populus tremula L.) and willow (Salix caprea L.) wood particles in a biopolymeric grid. Canine bone test examples were utilized for testing the physical, mechanical, and warm properties, and microstructure of biocomposites.

RESULTS AND DISCUSSIONS

The experimental outcomes are shown and talked about in this segment. Normal upsides of three replications of the Tractable test, Hardness test and the Effect test.

Tensile Strength

The malleable tests were performed utilizing a testing machine model 8889. The width and the thickness of the examples were estimated and recorded (360 mm by 20 mm by 5 mm). The malleable tests were completed by ASTM D 038-01. The elastic qualities were determined from this test.

Table 3.1 Tensile Properties of Jute fibre

S NO.	Weight of jute fibre (gm)	Weight of PP (gm)	Maximum Stress (MPa)
1	20	250	45
2	30	250	43
3	40	250	41
4	50	250	39
5	60	250	38

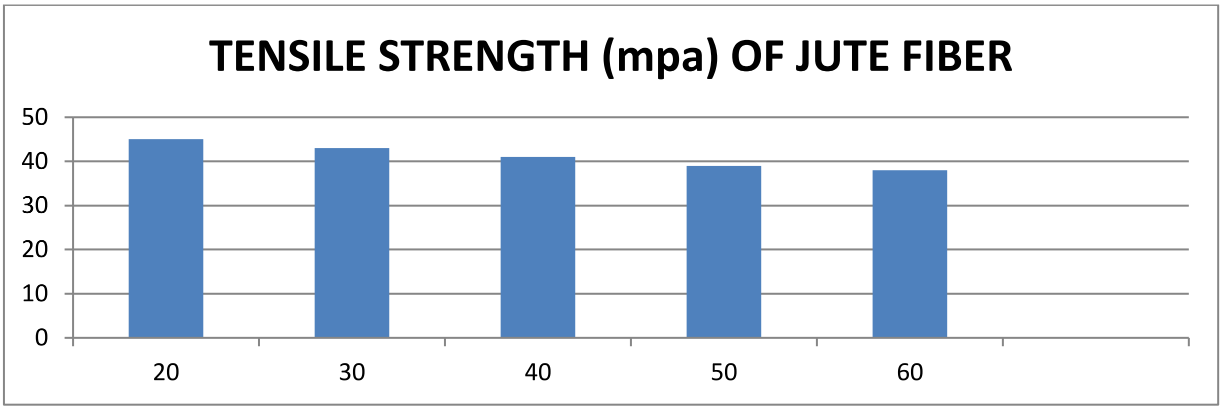

Fig 3.1

On testing on universal testing machine we achieve tensile strength as per 20gm of jute fiber and 250gm of Polypropylene (PP) we get maximum permissible stress is 45mpa similarly on 30gm, 40gm, 50gm, 60gm we get maximum permissible stress(mpa) is 45, 43, 41, 39 and 38 respectively.

Table 3.2: Tensile properties of flax fiber

S NO.	Weight of Flax fibre (gm)	Weight of PP (gm)	Maximum Stress (MPa)
1	20	250	50
2	30	250	55
3	40	250	60
4	50	250	62
5	60	250	64

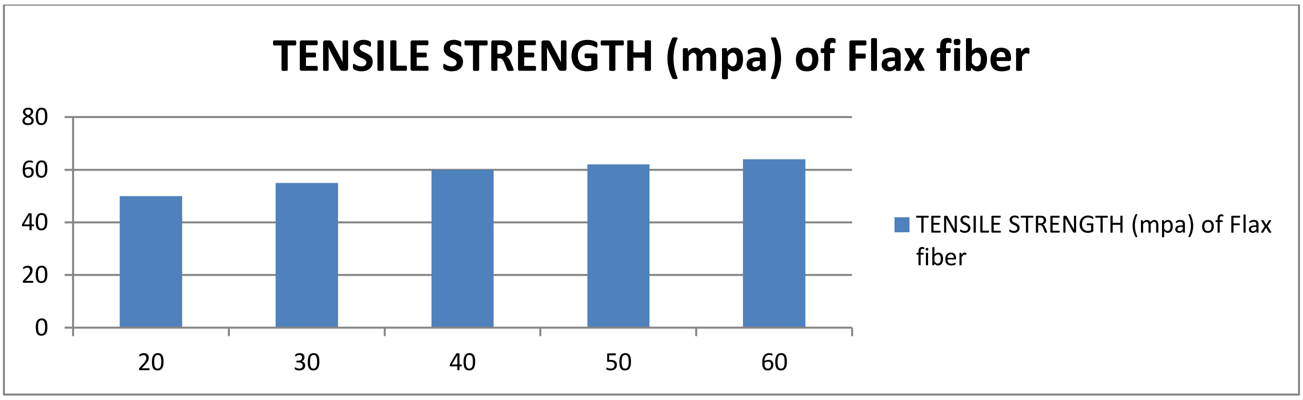

Fig 3.2

similarly on flax fiber tensile strength. The maximum permissible stress (mpa) is 50, 55, 60, 62, 64 on flax fiber weight ratio that is 20, 30, 40, 50, 60(gm) Respectively.

6.3 Impact Strength

The impact strength of jute laminate hybrid composites is presented in Below table. It is observed that the laminate composite is exhibiting higher impact strength than the wood reinforced composite. The jute hybrid composite impact strength is higher than wood reinforced composite but lower than glass fiber reinforced composite.

Table 3.3: Impact Properties of jute fibre

S NO.	Weight of jute fibre (gm)	Weight of PP (gm)	Impact Strength (KJ/m2)
1	20	250	14
2	30	250	17
3	40	250	19
4	50	250	21
5	60	250	25

fig 3.3

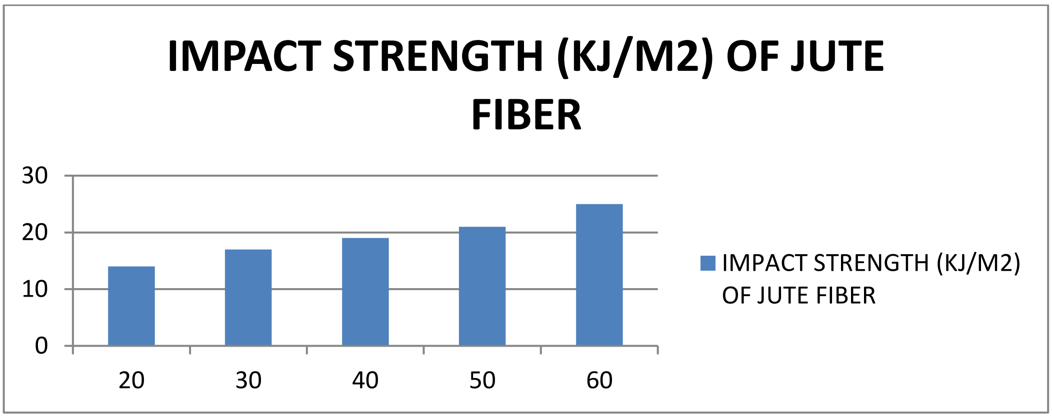

Table 3.4: Impact Properties of Flax fibre

S NO.	Weight of Flax Fiber (gm)	Weight of PP (gm)	Impact Strength (KJ/m2)
1	20	250	37
2	30	250	34
3	40	250	32
4	50	250	28
5	60	250	26

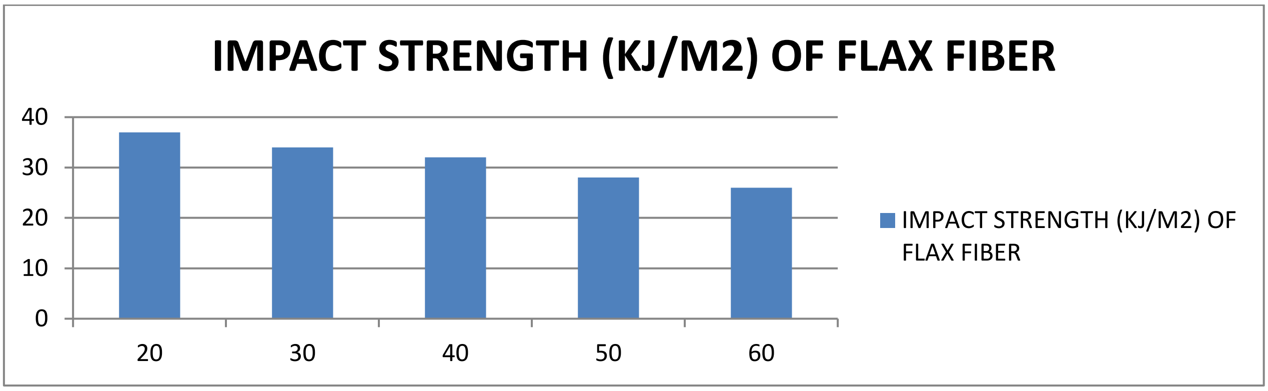

fig 3.4

The Impact testing test was conducted on Charpy pendulum Impact testing machine the Impact load is applied on the specimen 20,30,40,50,60 Respectively and the impact strength is achieved 37,34,32,28,26 (KJ/M^2).

Hardness Test

The Hardness test of jute and wood fibres composites is presented in Below Table. It is observed that the laminate composite is exhibiting hardness.

Table 3.5: Hardness Properties of Jute fibre

S NO.	Weight of jute fibre (gm)	Weight of PP (gm)	Hardness (HRB)
1	20	250	50
2	30	250	53
3	40	250	56
4	50	250	60
5	60	250	63

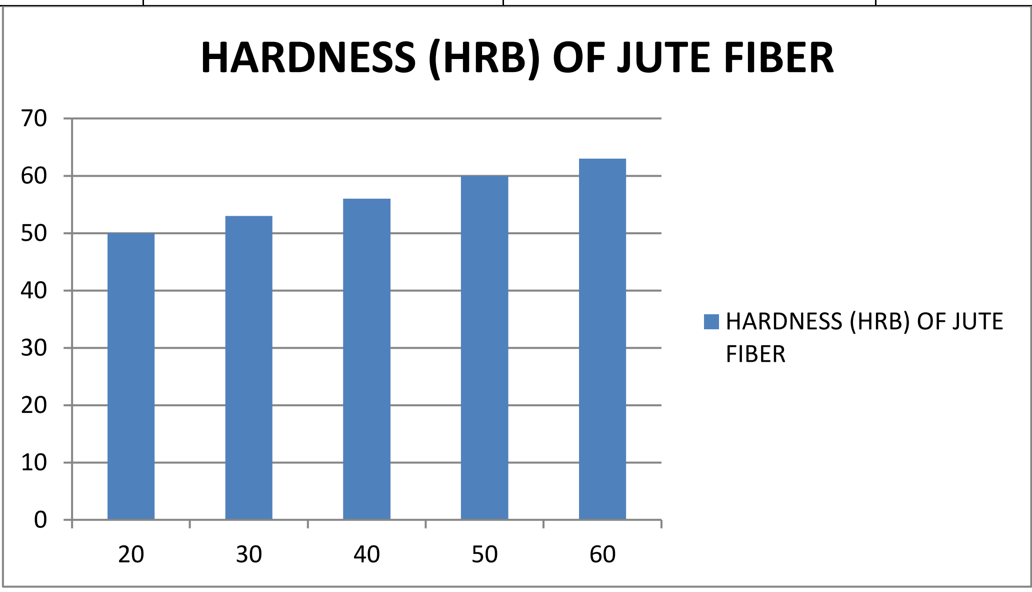

fig 3.5

Table 3.6: Hardness Properties of Flax fibre

S NO.	Weight of Flax fibre (gm)	Weight of PP (gm)	Hardness (HRB)
1	20	250	74
2	30	250	71
3	40	250	68
4	50	250	64
5	60	250	62

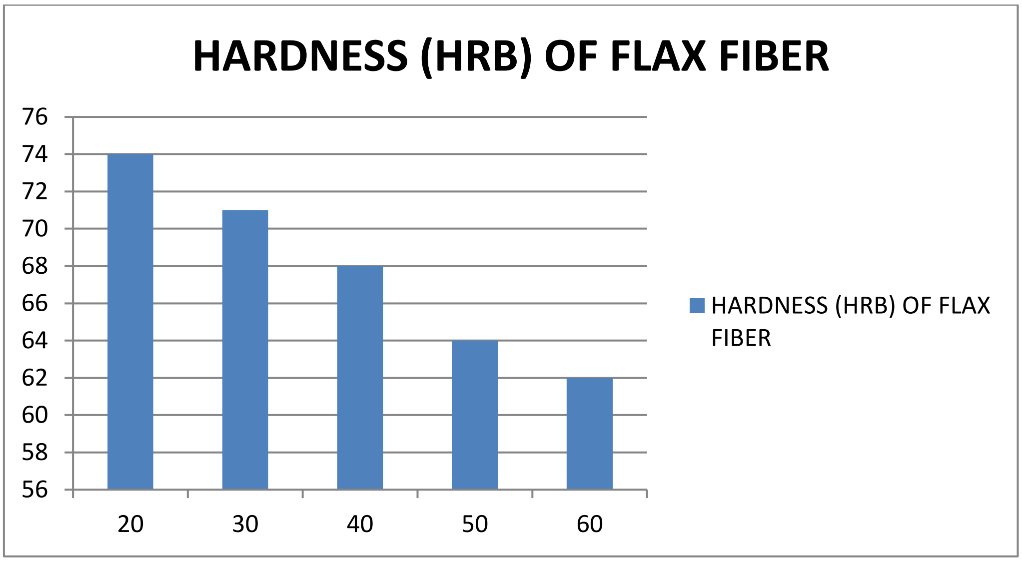

Fig 3.6: WEIGHT % OF FLAX FIBER (GM)

CONCLUSION

In conclusion, the fabrication and testing of biocomposite materials using jute fiber and flax fiber have shown tremendous potential in various applications. Through extensive research and experimentation, it has become evident that these natural fibers possess exceptional mechanical properties and environmental advantages, making them suitable alternatives to traditional synthetic fibers. The most common way of creating biocomposites includes the blend of jute and flax filaments with a biodegradable network material, for example, a bio-based pitch or polymer. This mixing method brings about a synergistic impact, where the normal filaments support the framework and upgrade the by and large mechanical strength of the composite material. Additionally, the use of natural fibers reduces the reliance on non-renewable resources and minimizes the environmental footprint associated with conventional materials. The testing phase plays a crucial role in determining the performance and suitability of biocomposite materials. Various tests, including tensile, flexural, impact, and water absorption tests, have been conducted to evaluate the mechanical and physical properties of the jute and flax fiber composites. The results have demonstrated impressive strength, stiffness, and durability characteristics, showcasing the potential for these materials in numerous industries such as automotive, construction, and packaging. Furthermore, the biodegradability and low carbon footprint of jute and flax fibers contribute to the overall sustainability of the biocomposite materials. As consumer demand for eco-friendly and renewable alternatives continues to grow, these biocomposites offer a promising solution by reducing dependence on fossil fuel-based materials and minimizing waste generation. Despite the significant progress made in the fabrication and testing of jute and flax fiber biocomposites, further research and development are warranted to optimize their properties and expand their applications. This includes investigating different fiber treatments, matrix materials, and manufacturing techniques to enhance the compatibility between the fibers and the matrix and improve overall performance. In conclusion, the fabrication and testing of biocomposite materials using jute and flax fibers have proven to be a viable and sustainable approach. With their impressive mechanical properties, environmental advantages, and potential applications, these biocomposites hold great promise in revolutionizing industries towards more sustainable and eco-friendly practices. Continued advancements and collaborations in this field will undoubtedly pave the way for a greener.

REFERANCES

1. Shukla, Premal. (2014). Biocomposites: Fabrication, Properties , and Applications – A Review,. International Journal of Innovative Research in Science, Engineering, and Technology.
2. Rao, K.M.M., Rao, K.M. and Prasad, A.R., 2010. Fabrication and testing of natural fibre composites:
3. Bledzki, A.K., Franciszczak, P., Osman, Z. and Elbadawi, M., 2015. This approach provides practical tools of how to tailor the properties of PP biocomposites by simply choosing an adequate fiber type as a matrix reinforcement.
4. Raman, Shanti & Chakraborty, S. & Kumar, C.S.S. & Chandran, Sharan. (2013). Fabrication and testing of jute Epoxy Biocomposite.
5. Ku, Harry & Wang, Hao & Pattarachaiyakoop, N. & Trada, Mohan. (2011). A review on the tensile properties of natural fiber reinforced polymer composites. Composites Part B: Engineering. 42. 856-873. 10.1016/j.compositesb.2011.01.010. This paper is a review on the tensile properties of natural fiber reinforced polymer composites.
6. Malkapuram, Ramakrishna & Kumar, Vivek & Negi, Yuvraj. (2009). Recent Development in Natural Fiber Reinforced Polypropylene Composites. Journal of Reinforced Plastics and Composites. 28. 1169-1189. 10.1177/0731684407087759.
7. Mirza, F. A. & Rasel, Sheikh & Afsar, A. & Kim, Byung & Song, Jungll. (2010). Injection molding and mechanical properties evaluation of short jute fiber polypropylene reinforced composites. WIT Transactions on the Built Environment. 112. 301-308. 10.2495/HPSM100281.
8. dzki, Andrzej & Faruk, Omar. (2006). Injection moulded microcellular wood fibre–polypropylene composites. Composites Part A-applied Science and Manufacturing - COMPOS PART A-APPL SCI MANUF. 37. 1358-1367. 10.1016/j.compositesa.2005.08.010.
9. Kumar, Anuj & Jyske, Tuula & Möttönen, Veikko. (2020). Properties of Injection Molded Biocomposites Reinforced with Wood Particles of Short-Rotation Aspen and Willow. Polymers. 12. 257. 10.3390/polym12020257.
10. Panigrahi, Satyanarayan & Li, Xue & Tabil, Lope. (2008). Injection moulding processing of flax fibre-research on using natural fibers